(b:) AMENDMENTS TO SPECIFICATION

In the title on page 1, line 1:

VEHICLE ~~BATTERY CHARGING~~ ELECTRICAL SYSTEM

In the paragraph beginning on page 2, at line 23:

The present invention is directed to an electrical system that satisfies the need for battery charging on a vehicle, ~~promoting~~ and promotes a longer service life for the battery and for accessory components installed on the vehicle. The electrical system comprises a lead acid battery having two terminals. A current sensor is coupled to one terminal of the battery for measuring current sourced from and delivered to the battery. A temperature sensor is positioned proximate to the battery for measuring battery temperature. A ~~charging~~ controllable voltage regulator ~~is provided~~ which is responsive to a control signal for adjustment of voltage on an output terminal of the regulator supplies a charging current to the battery. The ~~charging~~ controllable voltage regulator has input and output terminals and is connected by the output terminal to one terminal of the battery for ~~controlling~~ supplying charging current delivered to the battery. An electrical system controller responsive to the measured current sourced from the battery and the measured battery temperature generates the control signal to be applied to the controllable voltage ~~charging~~ regulator. Energization of the components is provided by an alternator connected to the input of the ~~charging~~ controllable voltage regulator. The system further includes a lighting system or low voltage circuit and a ~~lighting system~~ low voltage regulator connected between the alternator and the lighting system circuit. Voltage on an engine control or high voltage circuit is regulated by an engine control circuit or high voltage regulator connected between the alternator ~~source~~ and the engine control circuit.

In the paragraph beginning on page 3, line 32:

Fig. 1 is a perspective view of a vehicle **11** and of a vehicle electrical system **10** installed on the vehicle. Vehicle electrical system **10** comprises a control network based on a serial data bus **18**. One node of bus **18** is an electrical system controller (ESC) **30**, a type of programmable body controller, which controls various discrete devices, including a charging regulator **21** for a battery **25**. ESC **30** also manages a number of vocational controllers connected to bus **18** as nodes. ESC **30** executes a battery charging management program which aims to keep the battery fully charged as well as controlling the charging regimen to extend battery service life beyond that normally seen in heavy duty truck operation. Vehicle electrical system **10** further includes power systems such as an alternator **15** and it includes voltage regulators **16**, **21** and **22**, which regulate the voltage on subsidiary electrical systems. The subsidiary electrical systems operate at different voltages. The subsidiary electrical systems include: a low voltage system for energizing lighting, etc.; an intermediate, controllable voltage level system for battery charging; and a high voltage level system providing power to fuel injectors.

In the paragraph on page 4, beginning at line 9:

Active vehicle components are typically controlled by one of a group of autonomous, vocational controllers, which include an instrument and switch bank **12**, a gauge cluster **14**, and an engine controller **20**, all of which, along with other local controllers, are connected to ESC **30** over serial data bus **18**. The autonomous controllers include local data processing and programming and are typically supplied by the manufacturer of the controlled component. For each autonomous controller there is a defined set of variables used for communications between the autonomous controller and other data processing components on the network or attached to the network. Gauge cluster **14**~~, transmission controller **16**~~ and engine controller **20** all communicate with electronic system controller **30**, which also monitors inputs received from the auxiliary instrument and switch bank **12** over

the serial communication link in harness **18**. Electronic system controller **30** may be programmed to override the normal response characteristics of the gauge cluster **14**~~,~~ ~~transmission controller 16~~ and engine controller **20**.

In the paragraph beginning on page 4, line 22:

~~Power~~ Subsidiary electrical systems provide power for recharging battery pack **25**, for illuminating electrical lamps **36** and for operating fuel injectors. Separate voltage regulators ~~may be~~ are provided for ~~one or more~~ the distinct ~~subsystems~~ subsidiary systems, including a ~~lighting~~ low voltage ~~sub~~system **19** for the electrical lamps **36** and ~~an engine fuel injection~~ a high voltage ~~sub~~system **17** for the engine fuel injectors. Of particular interest here is a ~~charging~~ controllable voltage regulator **21** used for regulating the recharging of ~~for~~ battery pack **25**, which hangs from a vehicle side rail **13**. The output voltage level of controllable voltage ~~Charging~~ regulator **21** is controlled by a control signal from ESC **30**, either directly, or over the network. In addition to executing a battery charging management program for determining the level of the control signal for the controllable voltage regulator **21**, ESC **30** may execute subsidiary battery diagnostic routines, the results of which may be displayed on gauge cluster **14**. ESC **30** may also demand increased engine output from engine controller **20** if required for maintaining, or optimal charging of, battery pack **25**.

In the paragraph beginning on page 4, at line 32:

Fig. 2 is a block diagram schematic of a vehicle electrical power system **100**. Electrical power system **100** is directed primarily to distributing electrical power generated by an engine **101** driven electrical power source **15**, such as an alternator, or generator. Electrical potential is induced in and rectified in power element **45** by a rotor **47**. The amount of power generated is controlled by feedback of the output voltage level by an excitation controller **49** which controls the current through magnetic field generating rotor

47. Power source **15** should provide a constant voltage D.C. output at a potential of about 14.3 volts.

In the paragraph beginning on page 5, line 7:

Power from alternator **15** may be applied to individual voltage regulators for energizing the three ~~or more~~ subsidiary electrical ~~sub~~systems 17, 19 and 57 of the vehicle power system **100**. ~~Three such subsystems are described here, a~~ The voltage level on high voltage ~~fuel injection~~ ~~sub~~system **17** is controlled ~~powered~~ by an ~~engine control~~ high voltage regulator **16**~~,~~. The voltage level on low voltage ~~a lighting~~ ~~sub~~system **19** ~~powered~~ is controlled by a ~~lighting circuit or 12 volt~~ low voltage regulator **22**, and a ~~battery subsystem~~ battery charging system **57** is controlled ~~57 powered~~ by ~~a charging~~ controllable voltage regulator **21**.

In the paragraph beginning on page 5, line 13:

Low voltage ~~Lighting~~ ~~sub~~system **19** provides electrical power to a plurality of lamps and other accessories which are designed for 12 volt operation at 12 volts. On trucks particularly, the large number of ~~lights~~ lamps economically justifies careful control of the voltage applied to the lamps to extend ~~the~~ their service lives ~~of such lamps~~. Vehicles which use a single voltage regulator off of an alternator are typically set at an overvoltage of about 2.5 volts to the output of the battery in order to assure that the battery is kept charged. ~~Reducing the potential to the design potential~~ Limiting the drive voltage to the lamps to 12 volts by isolating the lamps from the overvoltages required to charge batteries can extend lamp life by an estimated 15%. As is conventional, lighting **39** is cutoff during engine cranking to conserve power. Here low voltage regulator **22** is disabled by a cranking indication signal applied as a cranking cut-off signal to the regulator.

In the paragraph beginning on page 5, line 22:

~~Engine control~~ A high voltage regulator ~~17~~ 16 provides power to high voltage system 17 which includes fuel injectors **37**. Here the voltage regulator **16** may advantageously be set to provide an output ~~at~~ of 14.3 volts.

In the paragraph beginning on page 5, line 25:

~~Charging~~ Controllable voltage regulator **21** ~~used to~~ controls the voltage level applied to the (usually) positive terminal of a battery pack **25** and does not have a fixed output level. Instead, the output voltage from ~~charging~~ controllable voltage regulator **21** is set by the value of a control signal supplied from electrical system controller **30**. The control signal is time varying and is set as a function in several variables. An output terminal of ~~charging~~ controllable voltage regulator **21** is connected to the positive terminals of battery (pack) **25**, which may include more than one six cell lead acid battery, connected in parallel. Illustrated are two such batteries **33** and **35**. Shown in parallel to batteries **33** and **35** are resistors **133** and **135** which represent the internal resistances of the corresponding batteries. The positive terminals of battery pack **25** ~~is~~ are also connectable by a switch **51** to a starter motor **39**.

In the paragraph beginning on page 6, line 1:

Instrumentation sensors are used to collect data for the battery charging control regimen ~~established by~~ programmed into electrical system controller **30**. Among these sensors are current sensors **131** and **137**, i.e. one for each of batteries **33** and **35** (collectively battery pack **25**). Current sensors **131** and **137** provide measurements both of current drawn from and delivered to the batteries. Electrical system controller **30** ~~can~~ integrates these signals to generate figures for total energy drawn from and returned to battery pack 25 (in watt-minutes). This in part allows the electrical controller **30** to assure

that as much current is returned to the batteries as is required to replace current drawn during starting. The instrumentation also allows setting the rate of current return at a level which will not damage the battery. A temperature sensor **139** provides temperature readings of the battery **25** to the electrical system controller, which allows losses during charging to be estimated and further allows certain diagnostic routines, which are not part of the invention, to be executed. Finally a voltage sensor **46**, connected to the positive terminal of battery pack **25** to provide voltage level signals to electrical system controller **30**, may be used ~~as well~~, primarily for diagnostic purposes ~~measures~~ and as a check to insure that during float charging, a minimum voltage to insure charge maintenance is applied to batteries **33** and **35**.

In the paragraph beginning on page 6, line 19:

During starting, current sensors **131** and **137** and voltage sensor **46** provide time varying signals indicating instantaneous current drawn from and output voltage supported by battery pack **25**. ESC **30** receives these signals and integrates them to determine the total current energy supplied in amp-minutes. After the engine starts, ESC **30** determines the power to be returned to battery pack **25**, including an amount to compensate for an estimation of losses based on battery history **43**. The rate at which current is to be returned is determined by reference to battery temperature. The voltage level provided by controllable voltage regulator thus is a function of battery temperature, battery current voltage and battery history **43**. Battery history may include anticipated run time of the vehicle engine **101**, which if short in duration leads to use of a higher charging current.

In the paragraph beginning on page 7, line 5:

~~Electrical power source~~ Alternator **115** provides electrical power induced in power element **145** by a rotor **147** which is driven by engine **101**. The amount of power generated is controlled by feedback of the output voltage level by an excitation controller

149 which controls the current through magnetic field generating rotor **147**. ~~Power source~~ Alternator **115** provides a rectified D.C. voltage output of about 42.0 volts.

In the paragraph beginning on page 7, line 10:

Power from alternator **115** is applied to individual the subsidiary electrical ~~sub~~systems of the vehicle power system **200**. These ~~sub~~systems include, a high voltage system 117 providing electrical power to a fuel injection ~~sub~~system ~~117~~ 337 powered directly from alternator ~~power source~~ **115**, a low voltage ~~lighting sub~~system **119** incorporating a 12 volt low voltage regulator **122** which in turn powers ~~a~~ lighting and other accessories ~~system~~ **39**, ~~and~~ a first battery charging ~~sub~~system **157** and a second battery charging system 257 which provide~~s~~ output power at two controllable levels through a two stage ~~charging~~ controllable voltage regulator **121**.

In the paragraph beginning on page 7, at line 16:

~~Lighting subsystem~~ Low voltage system **119** provides electrical power at 12 volts to a plurality of lamps and other accessories which are designed for 12 volt operation~~,~~. Low voltage system 119 ~~which~~ is essentially unchanged from the embodiment described with reference to **Fig. 2**~~.~~ except that low voltage regulator 122 must handle stepping voltage down from 42 volts to 12 volts instead of from 14.5 volts to 12 volts.

In the paragraph beginning on page 7, at line 24:

~~Charging~~ Two stage controllable voltage regulator **121** is used to control the voltage level applied to the (usually) positive terminal of 12 volt battery pack **25** (two parallel connected batteries **33** and **35**) and a second voltage level applied to an output terminal from series connected batteries **82**, **84** and **86**. Two stage controllable voltage regulator 121 does not have fixed output levels. Instead, the output voltages from ~~charging~~ controllable voltage regulator **121** ~~is~~ are set by control signals supplied from electrical

system controller **130**. The control signals ~~is~~ are time varying and ~~is~~ are set as ~~a~~ functions in several variables. An output terminal of ~~charging~~ controllable voltage regulator **121** is connected to the positive terminals of battery (pack) **25**~~, which may include one or more six cell lead acid battery connected in parallel~~. ~~Illustrated are two such batteries 33 and 35.~~ The positive terminals of battery pack **25** ~~is~~ are also connectable by a switch **51** to a starter motor **39**. A second output terminal of two stage controllable voltage regulator **121** provides power to charge series connected batteries **82**, **84** and **86**, which are six cell lead acid batteries of convention construction. These batteries are ~~similarly~~ instrumented similarly to batteries **33** and **35**. The series connected batteries **82**, **84** and **86** are connected by a diode **80** to a main power bus to supply initial power to fuel injectors **137**. The diode **80** prevents direct charging of the series connected batteries **82**, **84** and **86** from alternator ~~power source~~ **115**.

In the paragraph beginning on page 8, at line 10:

The battery charging regimen is represented in the high level flow chart of **Fig. 4**. Initially current drawn is measured and integrated at step **301** until an engine starts (step **303**). The battery temperature is then measured (step **305**) in order to set an initial charge rate (step **307**). Charging begins and current into the battery is monitored (step **309**). Battery temperature continues to be monitored and if the time rate of change of battery temperature exceeds a delta limit (step **311**), the control signal to the charging regulator is adjusted (step **313**) to step down the voltage output from the charging regulator. The cycle continues until the battery charge has been replaced, including an allowance for internal losses (step **315**). A battery ~~loss~~ state of charge estimate may be obtained from the battery history ~~table~~ 43 or a technical specification of the battery and the battery temperature. Temperature changes and rates of changes should fall within certain limits and a temperature transition outside of those limits can indicate battery damage. Once battery charge is replaced the control signal is reset to set the output voltage or voltages of

the ~~charging~~ controllable regulators **21** or **121** to maintain a float charge to ~~the~~ battery pack **25** and/or to batteries **82**, **84** and **86** to compensate for current leakage (step **317**).